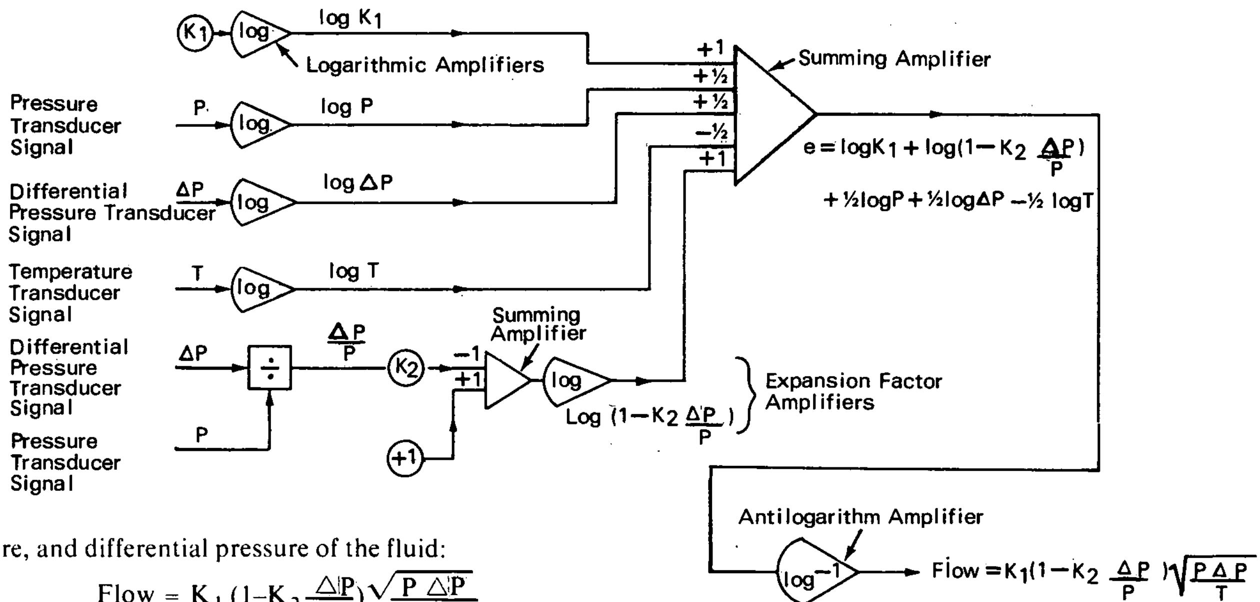
NASA TECH BRIEF

Lewis Research Center

Low Cost, Logarithmic Mass Flow Computer

A low cost logarithmic flow computer developed from standard components can solve the equation relating gas flow through a nozzle, venturi, or orifice to the absolute temperature, absolute pressure, and differential pressure of the fluid:



$$\text{Flow} = K_1\left(1-K_2\frac{\Delta P}{P}\right)\sqrt{\frac{P\,\Delta P}{T}}$$

where K_1 is a gain term, K_2 is a scaling term, P is the absolute pressure, ΔP is the pressure differential, and T is the absolute temperature. Transducers measure the parameters and convert them to electrical signals.

Other available flow computers that use standard components, such as commercial multipliers, dividers, and square root devices, are more complex and costly. Commercial process computers have a low frequency response, as do digital computers. The latter are also costly and complex, require analog to digital converters for the transducer output signals, and have an undesirable staircase output signal.

The new computer eliminates these problems by converting the analog signals to logarithmic form by scaling and summing the logarithms and then extracting the antilogarithm to obtain the analog flow. This technique eliminates the difficult divide and multiply functions otherwise involved.

The computer (see fig.) first converts the transducer output signals to logarithms and then sums them to give $1/2 \log P + 1/2 \log \Delta P - 1/2 \log T$. The expansion factor $(1-K_2\Delta P/P)$ is derived by scaling the ratio $\Delta P/P$ and subtracting it from 1. The logarithm of this term is added to those obtained previously to give the following:

$$\log\left(1-K_2\frac{\Delta P}{P}\right) + 1/2 \log P + 1/2 \log \Delta P - 1/2 \log T$$

(continued overleaf)

Finally, an overall gain term K_1 is added logarithmically to provide final scaling of the output. The output of the summing amplifier is then the logarithm of the desired equation:

$$e = \log K_1 + \log(1 - K_2 \frac{\Delta P}{P}) + 1/2 \log P + 1/2 \log \Delta P - 1/2 \log T$$

The output amplifier takes the antilogarithm of the above expression, giving:

$$\text{Output} = \text{Flow} = K_1 (1 - K_2 \frac{\Delta P}{P}) \sqrt{\frac{P \Delta P}{T}}$$

This logarithmic technique provides an exact solution of the flow equation and requires no analog/digital interface. The method is inexpensive, has a high-frequency response, and provides a true analog output.

Notes:

1. The cost of the logarithmic mass flow computer is approximately one fourth that of existing digital computers used for the same purpose.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B71-10407

Patent status:

No patent action is contemplated by NASA.

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